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Center for Electronics and Electrical Engineering

Technical Publication Announcements

Covering Center Programs, October - December 1984 with 1985 CEEE Events Calendar

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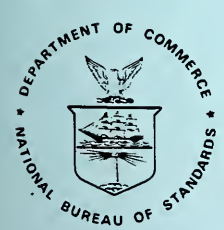

INTRODUCTION TO THE CEEE TECHNICAL PUBLICATION ANNOUNCEMENTS

This is the third issue of a quarterly publication providing information on the technical work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Publication Announcements covers the fourth quarter of calendar year 1984.

Organization of Bulletin: This issue contains citations and abstracts for Center papers published in the quarter. Entries are arranged by technical topic as identified in the table of contents and alphabetically by first author under each subheading within each topic. Following each abstract is the telephone number of the individual to contact for more information on the topic; unless otherwise noted, this person is the first author. This issue also includes a calendar of Center conferences and workshops now planned for calendar year 1985, an announcement of newly released standard reference materials, and a list of sponsors of the work.

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U. S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Materials and Processes and Semiconductor Devices and Circuits Divisions in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electrosystems Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Center sponsors: The Center Programs are sponsored by the National Bureau of Standards and a number of other organizations, in both the Federal and private sectors; these are identified on page 15.

Note on Publication Lists: Guides to earlier as well as recent work are the publication lists covering the work of each division. These lists are revised and reissued on an approximately annual basis and are available from the originating division [publications from the Semiconductor Technology Program are covered in a single list, available from either Semiconductor Division].

TABLE OF CONTENTS

INTRODUCTION . . . . . inside front cover

SEMICONDUCTOR TECHNOLOGY PROGRAM

Silicon Materials 2

Analysis Techniques 2

Insulators and Interfaces 2

Dimensional Metrology 3

Gallium Arsenide Materials 3

Integrated Circuit Test Structures 3

Process and Device Modeling 4

Radiation Effects 5

SIGNALS AND SYSTEMS METROLOGY PROGRAM

FAST SIGNAL ACQUISITION, PROCESSING, & TRANSMISSION 6

Waveform Metrology 6

Cryoelectronic Metrology 6

Antenna Metrology 7

Noise Metrology 8

Laser Metrology 8

Optical Fiber Metrology 8

Other Fast Signal Topics 9

ELECTRICAL SYSTEMS 10

Power Systems Metrology 10

Superconductors 11

Magnetic Materials and Measurements 11

ELECTROMAGNETIC INTERFERENCE 12

1985 CEEE CALENDAR 13

NEW STANDARD REFERENCE MATERIALS 14

SPONSOR LIST 15

KEY CONTACTS IN CENTER, CENTER ORGANIZATION . . . . . back cover

SEMICONDUCTOR TECHNOLOGY PROGRAM

Silicon Materials

Ehrstein, J.R., Downing, R.G., Stallard, B.R., Simons, D.S., and Fleming, R.F., **Comparison Depth Profiling of ^{10}B in Silicon Using Spreading Resistance Profiling, Secondary Ion Mass Spectrometry, and Neutron Depth Profiling,** ASTM Special Technical Publication 850, D.C. Gupta, Ed., pp. 409-425, ASTM, 1916 Race Street, Philadelphia, PA 19103 (October 1984).

Depth profiling of intentional dopants is an important measurement in the semiconductor industry both for process and device modeling and for process control. A comparison of ^{10}B implants into silicon as measured by Spreading Resistance Profiling (SRP), Secondary Ion Mass Spectrometry (SIMS), and by Neutron Depth Profiling (NDP) is presented. The boron implantations were done at several fluences and energies into bare silicon and through several thicknesses of thermally grown oxides. Sources of error and their relation to observed differences among the techniques are discussed.
[(301) 921-3625]

Analysis Techniques

Baghdadi, A., **The Effects of Instrumental Artifacts on the Quantitative Determination in Silicon by FTIR,** ASTM Special Technical Publication 850, D.C. Gupta, Ed., pp. 343-357, ASTM, 1916 Race Street, Philadelphia, PA 19103 (October 1984).

The evolution of silicon processing technologies towards greater reliance on internal gettering by oxygen precipitates has led to the need for greater precision in the measurement of the interstitial oxygen content of silicon slices. This measurement is presently being carried out with the use of Fourier Transform Infrared (FTIR) spectrophotometers. This paper concerns the investigation of the effects of changing the apodization function and beam geometry on the quantitative determination of oxygen in silicon by FTIR. The apodization functions used include the boxcar, cosine, Happ-Genzel, and triangular functions. The beam geometry is varied by placing apertures between the interferometer and the silicon specimen. The effects of beam polarization and detector nonlinearity were also investigated.
[(301) 921-3625]

Insulators and Interfaces

Candela, G.A., and Chandler-Horowitz, D., **An Ellipsometry System for High Accuracy Metrology of Thin Films,** Proc. SPIE - The International Society for Optical Engineering, 480, Integrated Circuit Metrology II, pp. 2-8, SPIE, P.O. Box 20, Bellingham, WA 98227 [paper given at Conference, Arlington, VA, May 2-3, 1984].

A computer-controlled spectroscopic ellipsometer of high accuracy has been designed and constructed. A theta-two-theta goniometer unit and optical rail system allows various ellipsometric methods to be used to measure the parameters Δ and ψ. Three important methods under study for accuracy, precision, and speed of measurement are the conventional null method, the rotating analyzer method, and the principal angle method. All the goniometer angles, including the angle of incidence, can be measured to an accuracy of 0.001 deg. The present light sources are two lasers with fixed wavelengths, 632.8 nm and 441.6 nm, in addition to a monochromator that can be used to scan the wavelength range from 190 to 2600 nm. A unique sample alignment system which utilizes two quadrant detectors has been developed and a simple but very effective nulling scheme is used. This instrument is primarily used for the metrology of semiconductor materials and for the calibration of reference standards for thin film thickness and refractive index.
[(301) 921-3625]

Dimensional Metrology

Nyyssonen, D., **Optical Linewidth Measurement on Patterned Metal Layers,** Proc. SPIE - The International Society for Optical Engineering, 480, Integrated Circuit Metrology II, pp. 2-8 [paper given at Conference, Arlington, VA, May 2-3, 1984].

In a previous paper, a waveguide model was developed for the imaging of micrometer-sized lines patterned in thick layers of dielectric materials (silicon dioxide) with application to linewidth measurement on integrated-circuit wafers. This paper describes the extension of this work to metals characterized by their complex index of refraction, n + iK, as well as the inclusion of a sublayer such as a silicon dioxide insulating layer. This extension allows the modeling of optical imaging and linewidth measurement on metal-on-silicon (MOS) structures. It is shown that the image structure for metals at and near focus is different from that for dielectrics. Thick and thin layer (less than 200 nm) imaging is compared. Experimental image profiles of metal lines at and near focus are also shown. The experimental data were obtained from a bright-field microscope using a laser source (530 nm) and controlled spatial coherence.
[(301) 921-3786]

Gallium Arsenide Materials

Seabaugh, A.C., Bell, M.I., Larrabee, R. D., and Oliver, J.D., **High-Frequency Transient-Resistance Spectroscopy of Deep Levels in Semi-Insulated GaAs,** Semi-Insulating III-V Materials: Kahneeta 1984, D.C. Look and J.S. Blakemore, Eds., pp. 437-445 (Shiva Publishing, Ltd., Cheshire, England, 1984).

A new photoinduced transient-resistance technique is used to characterize deep levels in semi-insulating GaAs. In this technique, termed photoresistance deep-level transient spectroscopy (PR-DLTS), an optical pulse is used to generate excess carriers which are trapped by deep levels in the material. The ac resistance of the specimen is monitored, and the resistance transient which occurs after the illumination ends is signal processed in the same way as the capacitance transient in conventional DLTS. Comparison of this technique with the dc current-transient measurement, photoinduced transient spectroscopy (PITS), shows that it is sensitive to the same trapping/detrapping phenomena. PR-DLTS data for the Cr-related deep level is consistent with published DLTS results. Results are reported for materials grown by the horizontal Bridgman method and by the liquid-encapsulated Czochralski technique, both with and without chromium doping. Nineteen specimens from ten different manufacturers are compared.
[(301) 921-3625]

Integrated Circuit Test Structures

Carver, G.P., and Wachnik, R.A., **TERRY-2: A Test Chip for Characterization of the Performance of Buried-Channel Charge-Coupled Device (CCD) Imagers,** NBSIR 84-2894 (December 1984).

Test chip TERRY-2 is intended to be used for characterization of the performance of buried-channel charge coupled device (CCD) imagers fabricated with a double-polysilicon-gate process which includes several implants. Test structures in TERRY-2 address two areas judged to be key ones for CCD performance: device parameters and process parameters, including material properties. TERRY-2 is a modular chip designed for automatic testing; selected devices can be wire bonded for testing various environmental effects; a region containing test structures can be thinned in the same manner as a back-side-illuminated CCD would be; and large devices can be beveled for spreading resistance or physical analysis. This report describes the features of TERRY-2, the test structure designs, and the measurement procedures. The technique of charge pumping for measuring interface state density is discussed

IC Test Structures, cont'd.

in an appendix.
[(301) 921-3786]

Process and Device Modeling

Albers, J., Wilson, C.L., and Blue, J.L., **The Effect of Bevel Angle and Number of Points on Spreading Resistance Data Analysis,** Extended Abstracts of the Electrochemical Society, 84-2, p. 727 (October 1984).

The semiconductor equations are used to obtain the carrier profile along a beveled structure. The spreading resistance is calculated on a scale much finer than the present experimental resolution of the technique. Spreading resistance algorithms are used on data spaced at the present experimental resolution. The difference between atomic and carrier densities along the bevel and the errors inherent in finite-layer algorithms are investigated. This is meant to provide insight into limitations of spreading resistance due to these sources.
[(301) 921-3621]

Bennett, H.S., **Dependence of Minority Carrier Lifetime on Doping Density in Heavily Doped Silicon,** Solid-State Electronics, 27, pp. 893-904 (October 1984).

The minority carriers determine the essential electrical characteristics of bipolar devices and bipolar-like parasitic paths in field effect devices. The electrical behavior of such devices is frequently described by detailed device models. Among the several input parameters for detailed device models, the dependences of the minority carrier lifetimes as functions of doping density have great uncertainty. Recent results from scattering theory for bandgap narrowing and Fermi energy as functions of doping density are included in the Shockley-Read-Hall expressions for the minority carrier lifetimes. The predicted lifetimes are concave from above with increasing doping for those processing conditions under which the doping and defect densities are not correlated strongly, whereas empirical expressions for the Shockley-Read-Hall lifetimes are convex with increasing doping density. Quantitative comparisons between theory and experiment are not possible because measurements of lifetime versus doping density have uncertainties associated with the separation of the Shockley-Read-Hall and Auger recombination mechanisms. A major finding of this research is that improved measurements are needed for minority carrier lifetime in heavily doped silicon as a function of doping density.
[(301) 921-3541]

Berkowitz, H.L., and Albers, J., **Simplified Method for Calculating Four-Probe Resistances on Nonuniform Structures,** Extended Abstracts of the Electrochemical Society, 84-2, p. 751 (October 1984).

A simple method for calculating the four-probe resistance as an integral involving only the kernel of the correction factor integral (and independent of the probe radius and the probe-current density) is presented. Analytic expressions are derived for uniform layers and are investigated as a function of the probe spacing. For nonuniform resistivity structures, a simple numerical procedure is presented for the evaluation of the four-probe resistance and is compared with more extensive techniques.
[Contact: Albers, (301) 921-3621]

Galloway, K.F., **Measurements for VLSI Models,** Proceedings of the Second International Workshop on the Physics of Semiconductor Devices, S.C. Jain and S. Radhakrishna, Eds. (Tata McGraw-Hill, New Delhi, 1984), pp. 98-105.

The complexity of VLSI makes an experimental approach to design and fabrication unrealistic. Accurate, computer-based models for simulating processes, devices, and circuits are required to

Process and Device Modeling, cont'd.

competitively develop VLSI technologies. The effectiveness of these models is often limited by the accuracy of the physical parameters used as input for the simulations. This paper summarizes results from two recent projects on measurement technology for obtaining parameters for VLSI models to illustrate the research in this area at the National Bureau of Standards.
[(301) 921-3541]

Wilson, C.L., and Blue, J.L., **Two-Dimensional Modeling of N-Channel MOSFETs Including Radiation-Induced Interface and Oxide Charge,** IEEE Transactions on Nuclear Science, NS-31, No. 6, pp. 1448-1452 (December 1984).

A model of the radiation-induced charges produced in n-channel MOSFETs is presented. The model is applicable for the unirradiated device and accurately predicts device characteristics for doses of up to 500 krad(Si). The model is verified by comparing the results obtained with the model to n-channel MOSFETs for doses of 0, 10, 50, 100, and 500 krad(Si). Detailed comparison of the model with a 7.8-μm channel length transistor, to eliminate short-channel effects, shows excellent agreement between the model and measured current-voltage characteristics in the subthreshold region, the triode region, and the saturation region. Analysis of the model parameters shows that the oxide charge and interface trap density are linear with dose in these devices. The mobility decrease used in the model can best be accounted for by the combined effects of scattering from oxide and interface charge in the channel.
[(301) 921-3541]

Wilson, C.L., Roitman, P., Marchiando, J.F., and Blue, J.L., **Modeling of the Process Sensitivity of Submicron Silicon MOSFETs,** Extended Abstracts of the Electrochemical Society, 84-2, p. 709 (October 1984).

When short-channel MOSFET transistor models are compared to experimental data, the uncertainty in the process models used as inputs often requires that some of the process model parameters be adjusted to fit the data. In this work the process sensitivity of the source-drain junction is modeled. We find that sensitivity of the saturated drain current to the source-drain junction depth increases sharply at some critical value of the junction depth. This value of junction depth is reached when the junction depth is equal to the zero biased depletion region width. As the contribution of the source drain junction to the sum of the depletion width and the junction depth becomes significant, the total change in channel field caused by the source-drain junction is a maximum.
[(301) 921-3541]

Radiation Effects

Gaitan, M., and Russell, T.J., **Measurement of Radiation-Induced Interface Traps Using MOSFETs,** IEEE Transactions on Nuclear Science, NS-31, No. 6, pp. 1256-1260 (December 1984).

The effect of gamma irradiation on the density of SiO_2/Si interface traps was measured using n- and p-channel MOSFETs. The density of traps was measured by a charge pumping measurement method and by a technique based on the slope of the transistor ln (I_d)-V_g characteristics in weak inversion. An increase in the density of interface traps with dose is observed with a greater increase just above compared to just below the center of the silicon bandgap.
[(301) 921-3621]

Galloway, K.F., Gaitan, M., and Russell, T.J., **A Simple Model for Separating Interface and Oxide Charge Effects in MOS Device Characteristics,** IEEE Transactions on Nuclear Science, NS-31, No. 6, pp. 1497-1501 (December 1984).

A simple model to describe radiation effects on MOSFET electrical character-

Radiation Effects, cont'd.

istics is presented. The key assumption is that mobility degradation in an enhancement mode MOSFET is predominantly due to charged interface traps. Model predictions are compared with measured values of interface trap density and device I-V curves.
[(301) 921-3541]

FAST SIGNAL ACQUISITION, PROCESSING AND TRANSMISSION

Waveform Metrology

Lawton, R.A., Nahman, N.S., and Bigelow, J.M., **A Solid-State Reference Waveform Standard,** IEEE Transactions on Instrumentation and Measurement, IM-33, No. 3, pp. 201-205 (September 1984).

A solid-state reference waveform filter has been developed which uses the Maxwell-Wagner capacitor effect. This filter is realized in a stripline configuration with a lossy dielectric consisting of a thick (5-μm) layer of SiO_2 on Si. The equivalent circuit of this filter is equivalent to that for previously developed filters which used a lossy liquid dielectric. A preliminary design has been completed and a filter fabricated for which the design characteristic impedance, 38 Ω, and transition duration (rise time), 300 ps, agree with measured values to within 2 and 17 percent, respectively. The temperature dependence of the filter transition duration has been estimated from the temperature dependence of the filter conductance to be about 1 percent/°C.
[(303) 497-3339]

Cryoelectronic Metrology

Hamilton, C.A., Lloyd, F.L., and Kautz, R.L., **High Speed Superconducting A/D Converter,** Proc. 1984 Government Microcircuit Applications Conference, Las Vegas, NV, Nov. 6-8, 1984, pp. 140-143.

Superconducting electronics has demonstrated impressive performance capabilities for small digital systems and analog signal processing applications. One of the areas where superconductivity offers a unique advantage is in ultra-high speed A/D conversion. This paper will describe the operation and current status of a 6-bit, 4 gigasample/s A/D converter which has been developed at NBS.
[(303) 497-3740]

McDonald, D.G., **Amplification by the Phase-Locking Mechanism in a Four-Junction SQUID,** Applied Physics Letters, 45, No. 11, pp. 1243-1245 (1 December 1984).

It is shown that the phase-locking property of an array of Josephson junctions can be used as a basis for amplification. The particular device simulated is a superconducting quantum interference device (SQUID) with four junctions in the loop, rather than the usual one or two. Novel consequences of this design are that it allows direct rather than inductive coupling to the SQUID and, because of its potentially compact form, it probably can have a bandwidth well into the gigahertz range, in agreement with the simulations.
[(303) 497-5113]

Niemeyer, J., Hinken, J.H., and Kautz, R.L., **Microwave-Induced Constant-Voltage Steps at One Volt from a Series Array of Josephson Junctions,** Applied Physics Letters, 45, No. 4, pp. 478-480 (15 August 1984).

It is demonstrated that a series array of 1474 Josephson junctions can produce quantized voltages up to 1.2 V when driven by microwaves at 90 GHz in the absence of a dc bias. This result brings closer the possibility of a practical Josephson voltage standard at the 1-V level.
[Contact: Kautz, (303) 497-3391]

Zimmerman, J. E., **Recent Developments in Self-Contained Cryocoolers for SQUIDs and Other Low-Power Cryoelec-**

Cryoelectronic Metrology, cont'd.

tronic Devices, Proc. Tenth International Cryogenic Engineering Conference, Helsinki, Finland, July 31-August 3, 1984, pp. 13-19.

The particular requirements of refrigeration for very low power cryoelectronic devices have been addressed only during the last few years. A number of laboratory prototypes are now near realization, and commercial systems may be available soon. These include Stirling and Gifford-McMahon machines and a four-stage Joule-Thomson machine, or a combination of one of the former with a final Joule-Thomson stage to achieve 4 K, and small liquid-helium cryostats with integral intermittent re-liquefying capability. The most difficult technical problem outstanding is to design reliable, non-contaminating, miniature compressors for these machines.
[(303) 497-3901]

Antenna Metrology

Kanda, M., **Transients in a Resistively Loaded Loop Antenna,** Proceedings of the 1984 International Symposium on Electromagnetic Compatibility, Tokyo, pp. 286-290 (October 16-18, 1984).

Transient characteristics of a loop antenna loaded uniformly with a resistive material are analyzed. The current distribution of the antenna is obtained by use of a Fourier series expansion technique. It is found that distortion of the transient waveforms due to resonance of a loop antenna can be reduced significantly and the received transient waveforms can be tailored by resistive loading.
[(303) 497-5320]

Newell, A.C., Francis, M.H., and Kremer, D.P., **The Determination of Near-Field Correction Parameters for Circularly Polarized Probes,** Proc. Annual Conference of the Antenna Measurement Techniques Association, Atlanta, GA, pp. 3A3-1 - 3A3-29 (October 2-4, 1984).

In order to accurately determine the far-field of an antenna from near-field measurements the receiving pattern of the probe must be known so that probe correction can be performed. When the antenna to be tested is circularly polarized, the measurements are more accurate and efficient if circularly polarized probes are used. Further efficiency is obtained if one probe is dual polarized to allow for simultaneous measurements of both components. A procedure used by the National Bureau of Standards for determining the plane-wave receiving parameters of a dual-mode, circularly polarized probe is described herein. First, the on-axis gain of the probe is determined using the three antenna extrapolation technique. Second, the on-axis axial ratios and port-to-port comparison ratios are determined for both the probe and source antenna using a rotating linear horn. Far-field pattern measurements of both amplitude and phase are then made for both the main and cross components. In the computer processing of the data, the on-axis results are used to correct for the non-ideal source antenna polarization, scale the receiving coefficients, and correct for some measurement errors. The plane wave receiving parameters are determined at equally spaced intervals in k-space by interpolation of the corrected pattern data.
[(303) 497-3743]

Wittmann, R.C., **Probe Correction in Spherical Near-Field Scanning, Viewed as an Ideal Probe Measuring an Effective Field,** 1984 International Symposium Digest, Antennas and Propagation, Vol. II, pp. 674-677 [paper given at IEEE Antennas and Propagation Society Meeting, Boston, MA, June 25-29, 1984].

In order to reduce measurement and computation complexity, most probe-corrected, spherical near-field scanning facilities use a special "symmetric" probe, the output of which exhibits a $\sin \chi$ -- $\cos \chi$ dependence as the probe is rotated about its axis by an angle χ.

Antenna Metrology, cont'd.

We show here that such a probe is mathematically equivalent to ideal dipole probes measuring an effective field. Computational efficiency and structural simplicity result, since much of the effort concerns the calculation of the effective field, and this may be accomplished with a no-probe correction algorithm.
[(303) 497-3326]

Noise Metrology

Daywitt, W.C., **A Preliminary Investigation Into Using the Sun as a Source for G/T Measurements**, NBSIR 84-3015 (August 1984).

This report describes a preliminary investigation into determining the solar flux density, the atmospheric correction factor, and the star shape correction factor for use in G/T measurements above 5 GHz. An estimate of errors is also included. Preliminary results show: an improved algorithm for determining diffusive and refractive attenuation; a viable technique for estimating the solar flux density from daily AFGL flux density measurements and a centimeter/millimeter wave spectrum function; and the possibility of reducing star shape correction factor errors by use of an effective solar rf diameter.
[(303) 497-3720]

Laser Metrology

Simpson, P.A., **A Computer-Controlled System for Calibrating Detectors of TEA Laser Pulses**, 22nd Automatic RF Techniques Group Fall 1983 Digest, Albuquerque, New Mexico, November 3-4, 1983, pp. 25-36 (May 1984).

A computer-controlled system for calibrating detectors of TEA laser pulse energy and waveforms is described. The operator merely inputs certain pertinent information about the measurements to be made and the system automatically performs the measurements and outputs the results.
[(303) 497-3789]

Simpson, P.A., Johnson, E.G., Jr., and Etzel, S.M., **A Calorimeter for Measuring High-Energy Optical Pulses**, NBSIR 84-3008 (October 1984).

Two similar calorimeters for measuring laser pulses in the range 1 kJ to 15 kJ are described. The calorimeters, which are electrically calibrated, can be operated anywhere from the ultraviolet to the infrared by selecting the proper materials for the volume absorber and deflecting mirror. Operation of each calorimeter is controlled by a dedicated desk-top computer. The theoretical basis for the calorimeters is given as are the constructional and operational details. The computer programs that are used are included in the appendices.
[(303) 497-3789]

Optical Fiber Metrology

Day, G.W., and Franzen, D.L., **Technical Digest - Symposium on Optical Fiber Measurements, 1984**, NBS Special Publication 683 (October 1984).

This volume contains summaries of 31 papers presented at the Symposium on Optical Fiber Measurements held October 2-3, 1984, at the National Bureau of Standards, Boulder, Colorado. Subjects include measurements on singlemode fiber, multimode fiber, fiber designed for sensing applications, instrumentation, field measurements, and standards.
[(303) 497-5204]

Engelsrath, A., Larson, D.R., Phelan, R.J., and Franzen, D.L., **Attenuation of Multimode Fused Silicon Optical Fibers Cooled to Liquid Helium Temperature**, Proc. SPIE - The International Society for Optical Engineering, 500, Fiber Optics: Short-Haul and Long-Haul Measurements and Applications II, pp. 124-130 [paper given at conference, San Diego, California, August 19-24, 1984].

Optical Fiber Metrology, cont'd.

The feasibility of bringing an optical signal through an optical fiber to a detection and processing system at liquid helium temperature was examined. The attenuation of three commercially available multimode optical fibers, from two different manufacturers with different buffer coatings, was measured under different cooling conditions. It was found that the attenuation depends on the cooling condition and has hysteresis effects. Independent of the λ tested (0.4-1.65 μm) the attenuation stayed below 0.1 dB/m under controlled slow cooling and under 0.5 dB/m with very fast cooling. Therefore, optical fibers can be used to bring optical signals into a liquid-helium-cooled dewar for detection and processing.
[Contact: Larson (303) 497-3440]

Maisonneuve, J.M., and Gallawa, R.L., **The Use of Power Transfer Matrices in Predicting System Loss: Theory and Experiment**, Proc. SPIE - The International Society for Optical Engineering, 500, Fiber Optics: Short-Haul and Long-Haul Measurements and Applications II, pp. 88-93 [paper given at conference, San Diego, California, August 19-24, 1984].

The phase space diagram for parabolic and step index fibers leads to a graphic representation of the bound, leaky, and refracted rays of ray theory. This concept is used to predict the attenuation of typical components of local area networds. The technique uses power transfer matrices to track the evolution of power distribution in ray packets. In particular, we predict and then measure the power transfer of two ray packets for a step index fiber. The comparison is encouraging.
[Contact: Gallawa, (303) 497-3761]

Other Fast Signal Topics

Belsher, D.R., McLaughlin, R.H., Repjar, A.G., and Bussey, H.E., **Microwave Detection of Lost Wells and Unknown Water-Filled Voids in Coal Mines**, NBSIR 84-3017 (September 1984).

Work on contract H0272007 is summarized for the period of January 1979 through March 1984. The development of improved antennas usable with both a pulse system or an FM-CW system is described. The development of a field prototype pulse sampling system is described. Initial theoretical work on the problem of dielectric loading of antennas as well as a study of potential system range is included.
[Contact: Repjar, (303) 497-5703]

Hill, D.A., **Radio Propagation in a Coal Seam and the Inverse Problem**, NBS Journal of Research, 89, No. 5, pp. 385-394 (September-October 1984) [related paper to be published at the Conference Proceedings of the International Symposium on Antennas and EM Theory, Beijing, China, August 24-26, 1985].

The longwall method of coal mining in underground coal seams is very efficient in uniform seams, but coal seam anomalies can make the method unprofitable and unsafe. This paper describes the theoretical basis for detection of coal seam anomalies using medium frequency (MF) radio transmission over paths on the order of 200 meters in length. The key to the method is the sensitivity of the attenuation rate of the coal seam mode of propagation to changes in the coal seam parameters, such as height or electrical conductivity. From a large number of transmission paths, the principles of tomography can be used to reconstruct an image of the seam.
[(303) 497-3472]

Lentner, K.J., Flach, D.R., and Bell, B.A., **An Automatic AC/DC Thermal Voltage Converter and AC Voltage Calibration System**, NBSIR 84-2973 (November 1984).

An automatic ac/dc difference calibration system is described which uses direct measurement of thermoelement

Other Fast Signal Topics, cont'd.

emfs. In addition to ac/dc difference testing, the system can be used to measure some important characteristics of thermoelements, as well as to calibrate ac voltage calibrators and precision voltmeters. The system operates over a frequency range from 20 Hz to 100 kHz, covering the voltage range from 0.5 V to 1 kV. For all voltages the total measurement uncertainties expected (including the uncertainty of the specific reference thermal converters used) were 50 parts per million (ppm) at frequencies from 20 Hz to 20 kHz, inclusive, and 100 ppm at higher frequencies up to 100 kHz. The results of initial intercomparisons between the new system and the manual NBS calibration system, using single-range, coaxial-type, thermal voltage converters as transfer standards, are reported. The results show that the agreement between the two systems is better than the uncertainties originally expected, since the intercomparison of ac/dc differences differed by no more than 15 ppm.
[(301) 921-2727]

Sanders, A.A., **Some Trends in Optical Electronic Metrology,** Proceedings of the 1984 Measurement Science Conference, R.M.S. Queen Mary, Long Beach, CA, January 19-20, 1984, pp. 27-33.

The use of optical related devices in high technology is expanding at a dramatic rate. Applications include the expanding use of optical fibers in telecommunications and sensors, lasers in industrial processing and medicine, optical storage devices, directed energy weapons for defensive purposes, nondestructive testing, -- the list goes on and on. The Optical Electronics Metrology Group of the National Bureau of Standards has the responsibility for developing the standards, measurement data, and methodology infrastructure for supporting much of this expanding technology. This paper will review some of the ongoing research conducted by this Group and some of the perceived important technological applications in this area for the next few years. It will discuss Group plans for developing the measurement infrastructure to support these innovations. The intent is to generate a dialogue to improve the Group's planning process and help sort out the most pressing priorities for optical measurements.
[(303) 497-5341]

Young, M., **Can You Describe Optical Surface Quality with One or Two Numbers?**, Proc. SPIE - The International Society for Optical Engineering, 406, Optical Specifications: Components and Systems, pp. 12-22 [paper given at conference, April 5-7, 1983, Arlington, VA].

This talk discusses two optical surface quality standards, total integrated scatter (TIS) and the scratch and dig standard (MIL-O-13830A). I begin by using Fourier optics to show that the well known expression, $I_t/I(0) = 4k^2\sigma^2$, which relates scattered power to rms roughness σ, is truly valid only for certain classes of surfaces. Vector scattering theory applied to a more general case shows that in fact optics can measure only a bandwidth limited roughness that can be related to scattered power only if the surface statistics are known. For this reason, the standard should perhaps be regarded as a scattered light standard and not as a surface roughness standard. I conclude by describing our use of a novel optical system to develop an objective measurement technique to aid in the manufacture of the artifacts used to implement the scratch standard.
[(303) 497-3223]

ELECTRICAL SYSTEMS

Power Systems Metrology

Hillhouse, D.L., **Outline of CCVT Calibration Procedure, EPRI-NBS Prototype System--Supplement to EPRI Report EL-690 (Field Calibration System for CCVTs, April 1978),** NBSIR 84-2987

Power Systems Metrology, cont'd.

(August 1984).

This report contains, in outline form, the step-by-step procedure for use of the EPRI-NBS Prototype Field Calibration System for Coupling Capacitor Voltage Transformers (CCVTs) in the calibration of CCVTs in the substation. It was prepared for the use of EPRI (Electric Power Research Institute) personnel at Waltz Mill, PA, where the system now resides. It is a supplement to the EPRI final report (EL-690, April 1978) on the project in which the system was developed.
[(301) 921-3121]

Superconductors

Clark, A. F., and Goodrich, L. F., **Characterization of a Standard Reference Superconductor for Critical Current and a Summary of Other Standard Research at NBS,** Proceedings of the Tenth International Cryogenic Engineering Conference, Helsinki, Finland, July 31-August 3, 1984, pp. 433-437.

A standard reference material can be useful for the calibration of measurement apparatus and interlaboratory comparison of research results. We have carefully characterized the first practical superconductor SRM for critical current and it is now available from NBS as "Standard Reference Material 1457 Superconducting Critical Current - NbTi Wire." The selection, characterization, and statistical analysis of this material will be described. The progress in other standards research will also be discussed for large conductor critical current, ac losses, stability, and critical field.
[(303) 497-3253]

Ekin, J.W., and Hong, M., **Electromechanical and Metallurgical Properties of Liquid-Infiltration Nb-Ta/Sn Multifilamentary Superconductor,** Applied Physics Letters, 45, No. 3, pp. 297-299 (1 August 1984).

Data are presented on the strain dependence of the critical current and critical field of Nb-Ta/Sn superconductors fabricated by the liquid Sn infiltration process. The results show that liquid infiltrated Nb-Ta/Sn superconductors have several significant advantages over bronze-process Nb/Sn super conductors: an overall J_c that is 3-10 times higher for magnetic fields in the range 13-20 T, an irreversible (damage) strain limit twice as large, and a J_c elastic-strain sensitivity less than half as large at fields above ~16 T. These improved properties are attributed to several unique characteristics of the liquid infiltration process: a tough Nb-Ta matrix, fine equiaxial A15 grains, and a uniform stoichiometric Sn concentration.
[(303) 497-5448]

Magnetic Materials and Measurements

Clark, A.F., and Cromar, M., **Design of the NBS Magnetic Monopole Detectors,** Proceedings of the Tenth International Cryogenic Engineering Conference, Helsinki, Finland, July 31-August 3, 1984, pp. 365-368.

Several different configurations of magnetic monopole detectors have been built and operated at the National Bureau of Standards. These have been designed based on the following objectives: (1) Study of the noise characteristics; (2) Simplicity and ease of changing configurations; (3) Operation in relatively large magnetic fields; and (4) Optimum detector area. Satisfying these objectives has resulted in several compromises, but also a flexible and useful apparatus for studying the behavior of the SQUID - detector loop combination with particular emphasis on noise sources that can simulate a monopole signal. Several sources of noise and techniques for their elimination will be discussed. Data from the spectral analysis of the noise signals is be presented.
[(303) 497-3253]

Magnetic Materials and Meas., cont'd.

Cromar, M., Clark, A.F., and Fickett, F.R., **Monopole Detection Studies at NBS,** Proceedings of the Conference on Monopole Detection by Induction Techniques, Ann Arbor, MI, October 5-9, 1983, pp. 477-480.

Magnetic monopole detectors have been under study and evaluation at NBS for the past year. This paper describes some of the work. It is the written version of a brief workshop contribution made at the MONOPOLE '83 conference held at the University of Michigan.
[(303) 497-5375]

Fickett, F.R., **Magnetic Measurements, Calibrations, and Standards: Report on a Survey,** NBSIR 84-3018 (October 1984).

The report summarizes the analysis of responses to a survey of industrial needs for magnetic services and research.
[(303) 497-3785]

ELECTROMAGNETIC INTERFERENCE

Juroshek, J.R., and Hoer, C.A., **A High-Power Automatic Network Analyzer for Measuring the RF Power Absorbed by Biological Samples in a TEM Cell,** IEEE Transactions on Microwave Theory and Techniques, MTT-32, No. 8, pp. 818-824 (August 1984).

A device for measuring the radiofrequency (RF) power absorbed by biological samples while they are being irradiated in a transverse electromagnetic (TEM) cell is described. The report discusses the design, calibration, and performance of this automated measurement system. The power absorption analyzer is based on a six-port type of automatic network analyzer, and operates at an incident power to the TEM cell of 1 to 1000 W, over a frequency range of 100 to 1000 MHz. Experiments show that an absorbed power of 0.02 to 0.05 percent of the incident power can be measured. Measurements of the power absorbed by a 1-percent saline solution were made using the power absorption analyzer and by an independent calorimetric measurement. The two measurement techniques show excellent agreement.
[(303) 497-5362]

Shafer, J.F., **Field Strength Levels in Vehicle Resulting From Communications Transmitters,** National Institute of Justice Report No. 200-83 (June 1984).

This report provides the results of an exploratory study to measure the electric field strength levels inside an automobile from communications equipment (transmitters and associated antennas) typical of that likely to be operated in and around the automobile as a law-enforcement vehicle. Field strengths were measured with a calibrated probe at 10 locations within the test vehicle, with and without the driver's door open, and with and without front-seat occupants, at frequencies representing the frequency bands of 25 to 50, 150 to 174, 400 to 512, and 806 to 866 MHz. Levels of output power are given for the data presented. Field strength levels are also given for the situation when a metallic prisoner shield or a personal transceiver is used in a vehicle, together with a mobile transceiver, in some cases. Also included are field strength measurements of speed measuring radar devices used in vehicles.
[Contact: Jesch, (303) 497-3496]

Wilson, P.F., Chang, D.C., and Ma, M.T., **Input Impedance of a Probe Antenna in a TEM Cell,** IEEE Transactions of Electromagnetic Compatibility, EMC-26, No. 4, pp. 154-161 (November 1984).

The input impedance of a probe antenna exciting a transverse electromagnetic (TEM) cell is analyzed via a variational formulation. The resulting impedance is shown to consist of two distinct terms; an ordinary rectangular waveguide contribution and a gap perturbation. Numerically generated curves for both are given and suggest that a simple alge-

Electromagnetic Interference, cont'd.

braic approximation for the input impedance should normally suffice. The resistive portion is found to be proportional to the square of the probe length, while the reactive portion is largely capacitive. These results should enhance the use of probes inserted in TEM cells either to excite or to measure fields.
[(303) 497-3842]

Wilson, P.F., and Ma, M.T., **Small Aperture Analysis of the Dual TEM Cell and an Investigation of Test Object Scattering in a Single TEM Cell,** NBS Technical Note 1076 (October 1984).

Small aperture theory is used to investigate the dual TEM cell. Analyzing coupling through an empty versus a loaded aperture leads to a model of dual TEM cell shielding effectiveness measurements. Small obstacle scattering yields results for both the field perturbation and the change in a cell's transmission line characteristics due to the presence of a test object in a TEM cell. In each case, theoretical values are compared to experimental data.
[(303) 497-3842]

1985 CEEE CALENDAR

July 15-18 (Boulder, CO)

National Conference of Standards Laboratories 1985 Workshop and Symposium: Managing Measurements to Achieve Quality. CEEE papers on waveform, microwave, and noise metrology. [Contact NCSL Secretariat MC104, Room 5001 Radio Building, NBS, Boulder, CO 80303]

July 22-24 (Monterey, CA)

1985 IEEE 22nd Annual Conference on Nuclear and Space Radiation Effects. This Conference will cover nuclear and space radiation effects and electromagnetic pulse effects on electronic devices, materials, circuits, and systems, as well as semiconductor processing technology and techniques for producing radiation-tolerant (hardened) integrated circuits. Specific topic areas are likely to include: basic radiation-effects mechanisms for materials and devices; radiation effects and spacecraft charging in satellites; radiation transport, energy deposition, dosimetry, and radiation facilities; methods of design and manufacturing for radiation-hardened electronic devices, integrated circuits, and the effects of radiation on these devices; electromagnetic pulse phenomena, assessment of coupling, and measurement technology; single-event upset and latchup phenomena; hardness assurance technology and testing techniques; radiation effects on the materials and electronics of nuclear reactors (power and space); and new developments and new technologies of interest to the nuclear and space radiation effects community.

The Conference is sponsored by the Radiation Effects Committee of the IEEE Nuclear and Plasma Sciences Society and cosponsored by the Defense Nuclear Agency, Sandia National Laboratories, and the Jet Propulsion Laboratory; the General Chairman for this Conference is K. F. Galloway, Chief of CEEE's Semiconductor Devices and Circuits Division. [Contact: Sandra B. Kelley (301) 921-3541]

July 23-25 (Vail, CO)

Short Course on Optical Fiber Measurements. [Contact: Robert L. Gallawa (303) 497-3761]

August 6-8 (Boulder, CO)

NBS EMI Metrology Short Course. The purpose of this course is to provide up-to-date information on instrumental methods for measuring electromagnetic interference. Topics to be covered include: relevant NBS measurement services; open-site measurements as related to FCC requirements; the use of TEM cells, anechoic chambers, reverberating chambers, and probes; measurements of

1985 CEEE CALENDAR, cont'd.

shielding effectiveness; and the electromagnetic environment, including conducted and outband EMI. Hands-on demonstration exercises in the NBS Boulder laboratories are part of this course, as is an FCC presentation on FCC practices and measurements. [Contact: Kent Zimmerman (303) 492-5151]

September 9-10 (Gaithersburg, MD)

VLSI Packaging Workshop. The IEEE Components, Hybrids, and Manufacturing Technology Society and NBS are jointly sponsoring this Fourth Annual Workshop. Attendees are expected to be specialists in the field and participate in discussions. Papers are planned in the following areas: VLSI package design, package thermal design, VLSI package interconnection options, package electrical issues, integrating package design, GaAs IC packaging, VLSI package materials advancements, die-attach solutions for VLSI packages, and new failure mechanisms in VLSI packaging. [Contact: Sandra B. Kelley (301) 921-3541]

November 5-6 (Gaithersburg, MD)

Workshop on Test Procedures for Precision Instrumentation and ATE Systems. The purpose of this Workshop is to promote the exchange of information among researchers, users, manufacturers, testing companies, and calibration laboratories on procedures for testing and verifying the performance of precision instrumentation and ATE systems. Sessions are planned to cover first-article/acceptance testing, bid-sample testing, writing specifications and procedures, minimum-use specifications, test accuracy ratios, the cost of testing contrasted with its benefits, case histories of specific testing programs, optimum calibration strategies, and recommended practices. [Contact: John R. Sorrells (301) 921-2727]

December 5 (Gaithersburg, MD)

1985 Power Semiconductor Devices Workshop. This Workshop is jointly sponsored by the IEEE Electron Devices Society and NBS and is held in conjunction with the IEEE Electron Devices Meeting in Washington, D.C., which it follows. Topic areas include: packaging, power integrated circuits, three-terminal devices, and modeling. The format of the Workshop calls for each topic area to be addressed by working groups of 15 to 30. Reports from the working groups will be developed and presented orally to all attendees in a concluding session. [Contact: Sandra B. Kelley (301) 921-3541]

NEW STANDARD REFERENCE MATERIALS

The first practical superconducting standard reference material (SRM) has been released by the Electromagnetic Technology Division to the NBS Office of Standard Reference Materials for sale to the public. The certified parameter of SRM 1457, Superconducting Critical Current -- NbTi Wire, is critical current at magnetic fields of 2,4,6, and 8 tesla at a temperature of 4.2 K and an electric field criterion of 0.2 μV/cm. Information is given to permit the user to determine critical current for temperatures in the range 3.90 to 4.24 K and electric field criteria from 0.05 to 0.2 μV/cm.

SRM 1457 consists of a 2.2-m length of a multifilimentary, niobium-titanium, copper-stabilized wire, wound in a single layer on a spool having a core diameter of 8.7 cm. The wire is evaluated for 34 parameters relating to current, voltage, magnetic field, temperature, strain, and physical specimen characteristics.

In conjunction with ASTM Standard Test Method B714-82, D-C Critical Current of Composite Superconductors, the new SRM is intended to provide means for calibrating apparatus used to measure key parameters of superconductor products and thus should be useful to buyers and sellers of superconductors, users of superconducting equipment, and researchers in superconducting technology.

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